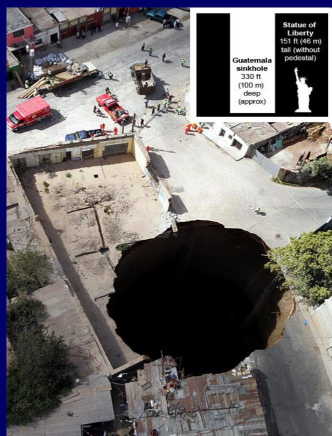
Preparing for the Geotechnical Field Investigation



David Thomas, Sr. Engineering Geologist
Office of Drilling Services

Where do I start?

Review Memo To Designers 1-35

LRFD

MEMO TO DESIGNERS 1-35 • JUNE 2008

SUPERSEDES MEMO TO DESIGNERS 1-35 DATED MARCH 1998

1-35 FOUNDATION RECOMMENDATION AND REPORTS

1. Overview

This memo defines the roles of the Structure Project Engineer (PE) and Geotechnical Services' design staff during the project development process.

Determination of the foundation configuration as early as possible in the project development process is one of the keys to keeping a project within budget and on schedule. Obtaining the necessary foundation design and construction recommendations in a timely manner is the result of good communication between Structure Design (SD) staff and Geotechnical Services (GS) staff throughout the life of the project.

The key to successful and timely development of foundation recommendations is frequent communication. Since the design process is iterative, periodic communication is required. Discussions between SD and GS personnel are required at, or prior to, the beginning of detailed design. An agreement between SD and GS is needed at this time as to the content and timing of the foundation recommendation deliverables.

The foundation design process begins with SD and GS staff collaborating as soon as possible to determine the design performance requirements (factored load demands and tolerable displacements), the limitations on the configuration or type of foundation system imposed by the site conditions, and a mutual understanding of the foundation alternatives being considered. As the design proceeds, the preliminary factored load demands and foundation configuration will be superseded by data developed by more accurate design analyses. It is essential that the revised parameters be communicated by SD to GS as the information is developed. Likewise, as the knowledge of the foundation conditions is developed and design analysis findings are determined, this information must be shared with SD as soon as possible.

The foundation design process, whether it is for shallow or deep foundations, is an iterative process. Foundation recommendations are dependent upon the factored load demands and the foundation configuration. The Foundation Report cannot be completed without a collaborative effort among SD, GS and all other involved functional units to develop and refine the foundation details.

1-35 FOUNDATION RECOMMENDATION AND REPORTS 1

Memo To Designers 1-35

Defines the roles of Structure Design and Geotechnical Services' design staff during the project development process

Table 2 - Overview of Tasks and Responsibilities of the SD and GS Design Staff

WBS Elements	Tasks	Structure Design Staff	GS Design Staff
Advance Planning Study (APS) (WBS 150, 160)	Advance Planning Study	Request Structure Preliminary Geotechnical Report (SPGR) from GS.	Acknowledge receipt of request and provide name of GS design staff assigned.
			Provide SPGR to SD.
Draft Structure PS&E (WBS 240)	Preliminary Foundation Report	Request Preliminary Foundation Report (PFR) from GS.	Acknowledge receipt of request and provide name of GS design staff assigned.
			Provide PFR to SD.
	Site Ready for Subsurface Exploration	Acknowledge status of site readiness for subsurface exploration.	Contact Structure PE regarding status of subsurface exploration. Report issues that potentially influence the project cost and/or schedule.
	Draft Structure General Plan	Discuss feasible foundation types prior to Type Selection with GS staff. Invite GS design staff to the Type Selection Meeting.	Discuss appropriate foundation types and recommended foundation types. Attend the Type Selection Meeting.
	Foundation Reports	Request Foundation Report (FR)	Acknowledge receipt of request and provide name of GS design staff assigned.
		Confirm or update the design loads and project schedule to GS design staff.	Prior to drilling, contact Structure PE to verify the foundation design data and schedule.
		Confirm or update foundation design data, including structure loads.	After drilling, contact Structure PE to discuss foundation design data.
		Verify/provide final foundation design data, including design structure loads to GS.	Acknowledge receipt of final foundation design data.
		Review FR. Contact GS design staff with comments.	Provide FR, including LOTBs to Structure PE.
	Draft Structure Plans	Request Draft Plans (Unchecked Details) review by GS design staff.	Send review comments to SD.
	Draft SPS&E	Request Draft SPS&E package review by the GS design staff.	Review Draft SPS&E. Send comments to SD and Structures Office Engineer (SOE).
Final Structure PS&E Package (WBS 250)	Project Review	Request review of final PS &E including constructability by GS. Review FR.	Update FR (if necessary). Issue foundation review/concurrence
Awarded & Approved Const. Contract (WBS 265)	Advertised Contract	SD/SOE request GS to respond to bidder inquiries.	Provide bidder inquiry response to SD and/or SOE.
Construction Engineering and General Contract (WBS 270)	Construction Engineering Work	SD/Structure Representative request technical support during construction (i.e., CRIP review, pile mitigation, foundation testing and CCO support).	Provide technical support to SD and Structure Representative.

Memo To Designers 1-35

Successful implementation of this process is completely dependent on the collaboration of the two design groups.

Establish a good working relationship.

Communicate, Communicate, Communicate ……

Review Memo To Designers 4-1 Spread Footings and Memo To Designers 3-1 Deep Foundations

LRFD

MEMO TO DESIGNERS 4-1 • APRIL 2008

SUPERSEDES MEMO TO DESIGNERS 4-1 DATED NOVEMBER 2003

4-1 SPREAD FOOTINGS

This memo is intended to clarify the terms and design methodology used in the current LRFD BDS (AASHTO LRFD Bridge Design Specifications, with Interims and California Amendments) for spread footings, and to improve communications with Geotechnical Services (GS).

Caltrans designs foundations at bents and pier footings in accordance with the LRFD BDS. By amendments to AASHTO LRFD Bridge Design Specifications, Caltrans designs foundations at the abutments based on the Working Stress Design (WSD) methodology (Caltrans Bridge Design Specifications LFD version of April 2000, based on 1996 AASHTO with Interims and Revisions by Caltrans). The LRFD Service I Limit State load combination is used as the design load in the WSD.

Definitions

Contact Surface = Bottom of the footing, located at a specific elevation.

Footing Width (B) = Short plan dimension of the footing.

Effective Footing Width (B') = Reduced footing width for an eccentrically loaded footing.

Footing Length (L) = Long plan dimension of the footing.

Effective Footing Length (L') = Reduced footing length for an eccentrically loaded footing.

q_o = Gross Uniform Bearing Stress. This is the equivalent uniform vertical stress determined by applying the vertical load over the effective footing area. Designer must include the weight of the footing and of all overburden soil from the contact surface to finished grade, when determining the gross uniform bearing stress.

q_{max} = Gross Maximum Bearing Stress. This is the maximum applied vertical stress demand at the contact surface. Gross maximum bearing stress demand must include the weight of the footing and of all overburden soil from the contact surface to finished grade. Used for footings on rock, q_{max} is based on triangular or trapezoidal stress distribution on the footing area.

q'_o = Net Bearing Stress. This is the gross uniform bearing stress for footings on soil or the gross maximum bearing stress for footings on rock minus the initial overburden or vertical effective stress at the contact surface. The net bearing stress due to LRFD Service I load combination is used to evaluate footing settlement.

4-1 SPREAD FOOTINGS 1

LRFD

MEMO TO DESIGNERS 3-1 • JULY 2008

SUPERSEDES MEMO TO DESIGNERS 3-1 DATED DECEMBER 2000

3-1 DEEP FOUNDATIONS

Deep foundations are structural assemblies that transfer load into deeper earth materials. Deep foundations, generically referred to herein as piles, can be driven piles, drilled shafts, or alternatively micropiles and grouted-in-place piles. Caltrans deep foundations consist of a single pile or a group of piles with a cap footing. Structure Design (SD) is responsible for calculating the pile load demands and for providing structure details. Geotechnical Services (GS) is responsible for providing foundation recommendations that include site seismicity, factored downdrag loads, pile tip elevations (based on the load demands provided by SD), construction recommendations (pile acceptance criteria, testing requirements, etc.), the Log of Test Borings, and Information Handouts. SD and GS will reach a consensus on pile type, size and special construction requirements, if any. SD is responsible for ensuring that the intent of the geotechnical and structural design is preserved in the contract plans and specifications. At the submittal of P&Q, any information absent from the Foundation Recommendations should be included in the project engineer's Memo to Specifications Engineer. When draft specifications are available, PS&E review by GS completes the process, allowing GS commentary on the plans and specifications. If necessary, a meeting with the specifications engineer, the geotechnical designer, and the SD's project engineer should occur to discuss the foundation related specifications.

Current Caltrans' practice is to design abutments in accordance with the Working Stress Design (WSD) methodology and bents/piers in accordance with the Load and Resistant Factor Design (LRFD) as specified in the current LRFD BDS (AASHTO LRFD Bridge Design Specifications (BDS) with interims, and Caltrans Amendments). Loads from the LRFD Service-I Limit State shall be used as design loads for WSD of the abutments. The structure designer needs to give the geotechnical designer the foundation design information and loads or demands for the applicable limit states, so that the geotechnical capacity of the pile selected will meet or exceed these demands. GS will provide factored nominal resistance and resistance factors for the applicable limit states. This information is used to calculate nominal resistance that will be shown in the Pile Data Table on the contract plans.

Standard Plan Piles

The Standard Plans, Sheets B2-3 (16" AND 24" CAST-IN-DRILLED-HOLE CONCRETE PILES), B2-5 (PILE DETAILS CLASS 90 AND CLASS 140), and B2-8 (PILE DETAILS CLASS 200) provide the upper limit of structural pile design capacities in tension and compression.

When a Standard Plan pile is specified, and unless otherwise specified in the Standard Plans or the contract Special Provisions, the contractor has the option of using any of the alternatives for that Class of pile. Should any of the alternative standard piles be infeasible to construct, that alternative must be disallowed in the contract Special Provisions or on the Pile Data Table.

3-1 DEEP FOUNDATIONS 1

Dry Creek Bridge (REP)

SD Request for Foundation Recommendations and Report

State of California
DEPARTMENT OF TRANSPORTATION
Memorandum

Business, Transportation and Housing Agency

Flex your power!
Be energy efficient!

To: GS Office Chief
Office of Geotechnical Design North

Date: April 30, 2009
File: 05-SB-2-PM 33.63
Dry Creek Bridge (Replace)
05-999999

From: SD Branch Chief
Bridge Design Branch 1
Office of Bridge Design North
DIVISION OF ENGINEERING SERVICES
STRUCTURE DESIGN

Subject: Request for Foundation Recommendation

Please provide Foundation Recommendations for the following structure in the above referenced project.

Dry Creek Bridge (Replace)
Br No. 51-0999

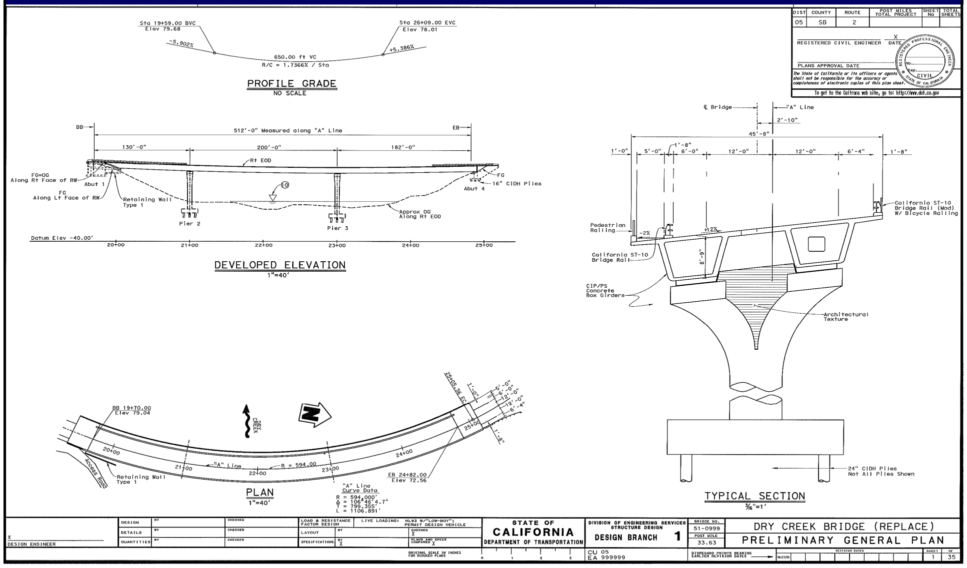
We are proposing a 3 span single column pier bridge. The center line of the new bridge is shifted approximately 50 feet to the east of the existing center line. We also need to build a forward retaining wall at Abutment 1R (east side) to retain a permanent access road. The forward retaining wall on Abutment 1R will be approximately 8ft (min) ~ 19ft (max) high and 45ft long. Standard Type 1 retaining wall has been assumed.

The abutment footings have been assumed to be on either 24 inch CIDH piles (Class 140) or spread footings. Piers have been assumed to be on either 24 inch CIDH piles (Class 200) with pile caps or 96 inch single CIDH plies. It has been assumed that spread footing can be used for the Standard Type 1 retaining wall for the forward wall. However, if soil bearing capacity is not adequate, please provide us specified tip elevations for 24 inch CIDH pile (Class 90).

Dry Creek Bridge (REP)

Preliminary General Plan

(included with the FR Request)



Dry Creek Bridge (REP)

Shallow Foundation Design and Load Data Tables

(included with the FR Request)

Table 1. Shallow Foundation General Data

Foundation Design Data Sheet						
Support No.	Design Method	Finished Grade Elevation (ft)	BOF Elevation (ft)	Footing Size (ft)		Permissible Settlement under Service Load (in)
				B	L	
Abut 1	WSD	480.5	476.5	15	52.67	1
Abut 4	WSD	475.5	471.5	15	47.67	1

Table 2. Shallow Foundation Load Data

Foundation Design Loads							
Support No.	Total Load				Permanent Load*		
	Vertical Load (kip)	Effective Dimensions (ft)		Horizontal Load in Long. Direction (kip)	Vertical Load (kip)	Effective Dimensions (ft)	
		B'	L'			B'	L'
Abut 1	3245	13.7	52.67	N/A	2703	14.3	52.67
Abut 4	3225	13.8	47.67	N/A	2629	14.5	47.67

Dry Creek Bridge (REP)

Deep Foundation Design Data Table (included with the FR Request)

Table 3. Deep Foundation General Information

Foundation Design Data Sheet								
Support No.	Design Method	Pile Type	Finished Grade Elevation (ft)	Cut-off Elevation (ft)	Pile Cap Size (ft)		Permissible Settlement under Service Load (in)	Number of Piles per Support
					B	L		
Abut 1	WSD	24” CIDH	480.5	476.75	9.0	52.67	1”	20
Pier 2 Alt. 1	LRFD	24” CIDH	483.5	466.25	28	39	1”	35
Pier 2 Alt. 2	LRFD	96” CIDH	483.5	472.0	N/A	N/A	1”	1
Pier 3 Alt. 1	LRFD	24” CIDH	482.0	466.25	28	39	1”	35
Pier 3 Alt. 2	LRFD	96” CIDH	482.0	472.0	N/A	N/A	1”	1
Abut 4	WSD	24” CIDH	475.5	471.75	9.0	47.67	1”	20

Dry Creek Bridge (REP)

Deep Foundation Load Data Tables (included with the FR Request)

Table 4. Deep Foundation Load Data

Foundation Design Loads												
Support No.	Service-I Limit State (kips)			Strength Limit State (Controlling Group, kips)				Extreme Event Limit State (Controlling Group, kips)				
	Total Load		Permanent Loads	Compression		Tension		Compression		Tension		
	Per Support	Max. Per Pile	Per Support	Per Support	Max. Per Pile	Per Support	Max. Per Pile	Per Support	Max. Per Pile	Per Support	Max. Per Pile	
Abut 1	2318	140	1776	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Pier 2 Alt. 1	8533	N/A	6587	10624	400	0	0	6587	400	0	200	
Pier 2 Alt. 2	6075	N/A	4129	7855	N/A	0	N/A	4129	N/A	0	N/A	
Pier 3 Alt. 1	9824	N/A	7875	12101	400	0	0	7875	400	0	200	
Pier 3 Alt. 2	6699	N/A	4750	8649	N/A	0	N/A	4750	N/A	0	N/A	
Abut 4	2635	140	2039	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	

Dry Creek Bridge (REP)

Scour Data Table

(included with the FR Request)

Table 5. Scour Data

Support No.	Long Term Scour Elevation (Degradation and Contraction) (ft)	Short Term Scour Depth (Local) (ft)
Abut 1	n/a	n/a
Pier 2	477	5
Pier 3	477	5
Abut 4	n/a	n/a

What do I need and how do I get it?

I want a drill rig now!

I want, I want, I want…

Hold on partner, not so fast!

-Do your homework first. Familiarize yourself with the available data.

-Contact Structure Design. Introduce yourself.

-Determine who your District Contacts are. You will need their assistance.

-Verify the PY's (hours) resourced for this project.

Schedule a field trip to the site

And No Drive by's, Walk the Site!

On your way there don’t forget to …

visit the nearest hospital to the site

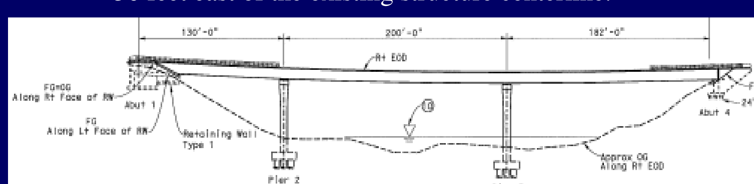
and when you reach the site …

check for cell phone reception.

Dry Creek Bridge (REP)

Overview Image – Looking West

Proposed replacement bridge will be offset
50 feet east of the existing structure centerline.



Dry Creek Bridge (REP)

Abutment 1

Cut Slope at Abutment 1 location with sandstone outcrop.

South access to Abutment 1 location.

Dry Creek Bridge (REP)

Abutment 4

Looking SW across Abutment 4 location.

North access to Abutment 4 location.

Dry Creek Bridge (REP)

Don’t forget to look for hazards.

Abutment 1 location.

Overhead electrical lines observed.

Abutment 4 location.

Buried electrical, natural gas pipeline and fiber optic line markers just off the roadway.

Dry Creek Bridge (REP)
Pier 2

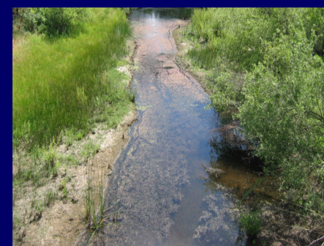
Looking east at Pier 2 location.

Sensitive wetland habitat with year round creek adjacent to Pier 2.

Dry Creek Bridge (REP)

Pier 3

Looking east at proposed Pier 3 location.



Pier 3 location is adjacent to sensitive wetlands habitat

Dry Creek Bridge (REP)

Watch Out Partner! Varmints!

Cute little fella’s, aren’t they……

Back from the initial site visit……

"time to plan the plan"

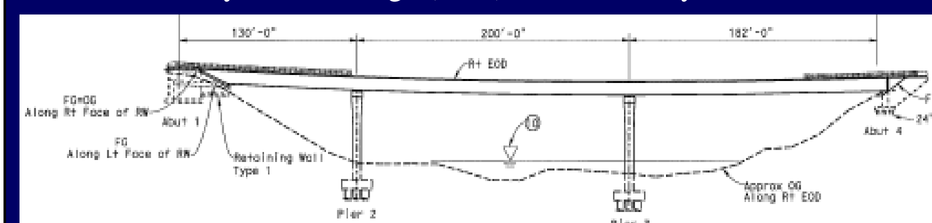
• Submit sandstone outcrop hand samples to the lab for point load index testing

• Contact Structure Design and confirm data

• Develop a subsurface exploration plan (for design and construction).

Planning the Subsurface Investigation (Drilling)

Dry Creek Bridge (REP) Site Summary



• Sandstone rock outcrop adjacent to Abutment 1

• Unknown depth to bedrock at Piers 2, 3, and Abutment 4. Loose sand and silt covers these 3 locations, unknown soil types below OG (original ground).

• Creek flows year round but is controlled by a small dam upstream

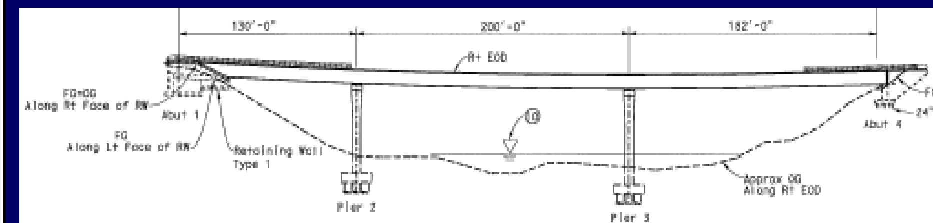
• No As-Built Log of Test Borings for the existing bridge

•Abutment 1 of existing bridge is on spread footing, remaining piers and abutment supported on 10 to 40 foot driven timber piles

Planning the Subsurface Investigation (Drilling)

Dry Creek Bridge (REP)

Guidelines for Determining Number of Test Borings and Where



- FHWA recommends a minimum of one test boring per bridge pier or abutment foundation less than 30 meters (100 feet) wide

- Single (non-redundant) CIDH (Drilled Shaft) pile foundations at bridge supports also warrant a minimum of one test boring

Planning the Subsurface Investigation (Drilling)

What are we investigating for?

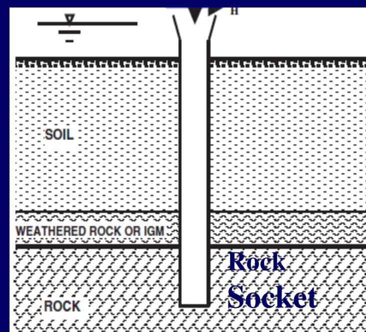
Abutments – Spread Footing or
24-in. CIDH piles (Class 200)

Piers 2 and 3 - 24-in. CIDH piles (Class 200) or
Single 96-in. CIDH (Drilled Shaft) piles

Retaining Wall @ Abut 1 – Spread Footing or
24-in. CIDH piles (Class 90)

Embankment Fill - $\leq$ 6-ft. @ Abut 1, 10-ft @ Abut 4

Drilled Shaft (Pile)



type of CIDH (Cast-in-Drilled Hole) Pile
built (drilled) directly into rock

Planning the Subsurface Investigation (Drilling)

Dry Creek Bridge (REP) - Test Boring Layout

a minimum of (4) Test Borings,
one at each support location would:

- adequately characterize the subsurface geology
- provide for a sufficient number of samples to determine geotechnical soil and rock properties

Planning the Subsurface Investigation (Drilling)

Dry Creek Bridge (REP) – Type of Test Borings

- the use of Mud-Rotary drilling is indicated for all (4) test borings as the site thus far has been characterized as sand and silt soil overlying bedrock.

Planning the Subsurface Investigation (Drilling)

Dry Creek Bridge (REP) – Sampling Plan

Perform Standard Penetration Tests (SPT's) at 5-foot intervals until encountering top-of-rock.

- bore hole in-situ test that allows you to collect soil samples (disturbed) for both field logging and laboratory classification
- the recorded blow count values per foot (N) are used to describe the apparent density of granular, non-cohesive soils (sand , silt and gravel)
- corrected blow count values (N') can be used to estimate soil strength and soil unit weight for non-cohesive soils
- SPT's performed in cohesive (clay) soils are less reliable for strength estimates
- these data can be used in the computation of soil bearing capacity and settlement for spread footing and pile design, embankment stability and liquefaction analysis

Planning the Subsurface Investigation (Drilling)

Dry Creek Bridge (REP) – Sampling Plan

Take Undisturbed 2.0 or 2.5-in. Brass Tube Samples at select intervals in cohesive (clay) soils for laboratory testing.

- Laboratory tests to consider for cohesive soils -

- PI (Plasticity Index) – classification
- UU (Unconsolidated Undrained) – undrained compressive strength
-
- C (Consolidation) – estimates the magnitude and rate of settlement

Planning the Subsurface Investigation (Drilling)

Dry Creek Bridge (REP) – Sampling Plan

Additional soils testing.

- Required Laboratory tests -

CR (Corrosion) – soil pH, chloride and sulfate concentrations, plus resistivity

- Field tests for cohesive soils -

- Pocket Penetrometer – unconfined compressive strength
- Pocket Torvane – undrained shear strength

Planning the Subsurface Investigation (Drilling)

Dry Creek Bridge (REP) – Sampling Plan

<u>Continuous Rock Core (94mm or Hxb)</u>
will be required once top-of-rock is reached

- Laboratory test for select intact rock core -

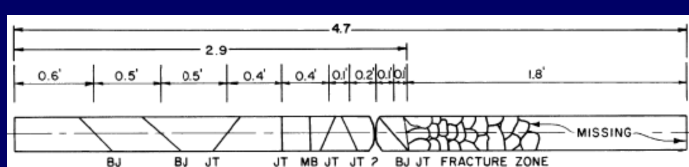
- UC (Unconfined Compression) – compressive strength

Planning the Subsurface Investigation (Drilling)

Dry Creek Bridge (REP) – Sampling Plan

<u>Determine %Recovery and Rock Quality Designation (RQD) from recovered rock core at each boring location.</u>

$$RQD = \frac{\text{Sum of length of pieces} \geq 0.33\,\text{ft (4in)}}{\text{(total length of core run)}} \times 100 = \frac{2.4}{4.7} \times 100 = 51\,\%$$



RQD Value	Description of Rock Quality
0% - 25%	Very poor
26% - 50%	Poor
51% - 75%	Fair
76% - 90%	Good
91% - 100%	Excellent

Measured in the field immediately after recovery from test boring

How deep should I drill?

Not too deep and not too shallow

Geotechnical Drilling is a very expensive business
($1,000's/day) and resources are limited

Remember, it's labeled exploratory for a reason

Planning the Subsurface Investigation (Drilling)

Dry Creek Bridge (REP)

Guidelines for Determining Test Boring Depths

- Spread Footings – where L is less than twice W, depth would be twice W below bearing level.
  where L is greater than 5 times W, depth would be 4 times W below bearing level.
- Drilled Shafts – three times the pile diameter below the anticipated shaft tip elevation or twice the maximum shaft group dimension, whichever is greater
- Retaining Walls on spread footing – 1.5 times the maximum wall height
- Embankment – twice the embankment height

Note: from AASHTO Standard Specifications for Design of Highway Bridges

Planning the Subsurface Investigation (Drilling)

Dry Creek Bridge (REP)

Estimated Test Boring Depths

Support	Foundation Type	Calculated Test Boring Depth	Scour	Est. Boring Depths	Actual Depths
Abut 1	Spread Footing	**46 feet**	NA	**50 feet**	**40 feet**
Ret Wall 19' H	Spread Footing	29 feet	NA	30 feet	
Pier 2	**24" CIDH Pile Group**	**78 feet**	21	**80 feet**	**85 feet**
Pier 2	Single 96" CIDH Pile	overlying soil + 54 feet Rock Core	21	75 feet	
Pier 3	**24" CIDH Pile Group**	**78 feet**	21	**80 feet**	**52 feet**
Pier 3	Single 96" CIDH Pile	overlying soil + 57 feet Rock Core	21	80 feet	
Abut 4	Sread Footing	42 feet	NA	50 feet	
Abut 4	**24" CIDH Pile Group**	**96 feet**	NA	**100 feet**	**100 feet**